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(54) Title: BATTERY HAVING PRINTED LABEL (57) Abstract A battery comprising a can and a label is provided in which the label comprises a print layer that is directly applied onto the can. Also provided is a method of preparing a battery having a label on a can, comprising directly applying a print layer onto the can. A primer layer may be applied directly under the print layer and an electrical insulation layer may be applied over the print layer. Because the print layer is directly applied, without a label substrate, the thickness of the label can be reduced, thereby allowing a corresponding increase in the battery can diameter and internal volume available for electrochemically active materials.		

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BATTERY HAVING PRINTED LABEL

The present invention generally relates to an electrochemical cell construction.
5 More particularly, the present invention relates to the containers used for an electrochemical cell, such as an alkaline cell.

Figure 1 shows the construction of a conventional C sized alkaline cell 10. As shown, cell 10 includes a cylindrically shaped can 12 having an open end and a closed end. Can 12 is preferably formed of an electrically conductive material, such that an
10 outer cover 11 welded to a bottom surface 14 at the closed end of can 12 serves as an electrical contact terminal for the cell.

Cell 10 further typically includes a first electrode material 15, which may serve
15 as the positive electrode (also known as a cathode). The first electrode material 15 may be preformed and inserted into can 12, or may be moulded in place so as to contact the inner surfaces of the can 12. For an alkaline cell, first electrode material 15 will typically include MnO_2 . After the first electrode 15 has been provided in can 12, a separator 17 is inserted into the space defined by first electrode 15. Separator 17 is
20 preferably a non-woven fabric. Separator 17 is provided to maintain a physical separation of the first electrode material 15 and a mixture of electrolyte and a second electrode material 20 while allowing the transport of ions between the electrode materials.

25 Once separator 17 is in place within the cavity defined by first electrode 15, an electrolyte is dispensed into the space defined by separator 17, along with the mixture 20 of electrolyte and a second electrode material, which may be the negative electrode (also known as the anode). The electrolyte/second electrode mixture 20 preferably includes a gelling agent. For a typical alkaline cell, mixture 20 is formed of a mixture of
30 an aqueous KOH electrolyte and zinc, which serves as the second electrode material. Water and additional additives may also be included in mixture 20.

Once the first electrode 15, separator 17, the electrolyte, and mixture 20 have been formed inside can 12, a preassembled collector assembly 25 is inserted into the open end of can 12. Can 12 is typically slightly tapered at its open end. This taper serves to support the collector assembly in a desired orientation prior to securing it in place. After collector assembly 25 has been inserted, an outer cover 45 is placed over collector assembly 25. Collector assembly 25 is secured in place by radially squeezing the can against collector assembly 25. The end edge 13 of can 12 is crimped over the peripheral lip of collector assembly 25, thereby securing outer cover 45 and collector assembly 25 within the end of can 12. As described further below, one function served by collector assembly 25 is to provide for a second external electrical contact for the electrochemical cell. Additionally, collector assembly 25 must seal the open end of can 12 to prevent the electrochemical materials therein from leaking from this cell. Additionally, collector assembly 25 must exhibit sufficient strength to withstand the physical abuse to which batteries are typically exposed. Also, because electrochemical cells may produce hydrogen gas, collector assembly 25 may allow internally generated hydrogen gas to permeate therethrough to escape to the exterior of the electrochemical cell. Further, collector assembly 25 should include some form of pressure relief mechanism to relieve pressure produced internally within the cell should this pressure become excessive. Such conditions may occur when the electrochemical cell internally generates hydrogen gas at a rate that exceeds that at which the internally generated hydrogen gas can permeate through the collector assembly to the exterior of the cell.

The collector assembly 25 shown in Figure 1 includes a seal 30, a collector nail 40, an inner cover 44, a washer 50, and a plurality of spurs 52. Seal 30 is shown as including a central hub 32 having a hole through which collector nail 40 is inserted. Seal 30 further includes a V-shaped portion 34 that may contact an upper surface 16 of first electrode 15.

Seal 30 also includes a peripheral upstanding wall 36 that extends upward along the periphery of seal 30 in an annular fashion. Peripheral upstanding wall 36 not only serves as a seal between the interface of collector assembly 25 and can 12, but also

serves as an electrical insulator for preventing an electrical short from occurring between the positive can and negative contact terminal of the cell.

Inner cover 44, which is formed of a rigid metal, is provided to increase the rigidity and support the radial compression of collector assembly 25 thereby improving the sealing effectiveness. As shown in Figure 1, inner cover 44 is configured to contact central hub portion 32 and peripheral upstanding wall 36. By configuring collector assembly 25 in this fashion, inner cover 44 serves to enable compression of central hub portion 32 by collector nail 40 while also supporting compression of peripheral upstanding wall 36 by the inner surface of can 12.

Outer cover 45 is typically made of a nickel-plated steel and is configured to extend from a region defined by the annular peripheral upstanding wall 36 of seal 30 and to be in electrical contact with a head portion 42 of collector nail 40. Outer cover 45 may be welded to head portion 42 of collector nail 40 to prevent any loss of contact. As shown in Figure 1, when collector assembly 25 is inserted into the open end of can 12, collector nail 40 penetrates deeply within the electrolyte/second electrode mixture 20 to establish sufficient electrical contact therewith. In the example shown in Figure 1, outer cover 45 includes a peripheral lip 47 that extends upwardly along the circumference of outer cover 45. By forming peripheral upstanding wall 36 of seal 30 of a length greater than that of peripheral lip 47, a portion of peripheral upstanding wall 36 may be folded over peripheral lip 47 during the crimping process so as to prevent any portion of the upper edge 13 of can 12 from coming into contact with outer cover 45.

Seal 30 is preferably formed of nylon. In the configuration shown in Figure 1, a pressure relief mechanism is provided for enabling the relief of internal pressure when such pressure becomes excessive. Further, inner cover 44 and outer cover 45 are typically provided with apertures 43 that allow hydrogen gas to escape to the exterior of cell 10. The mechanism shown includes an annular metal washer 50 and a plurality of spurs 52 that are provided between seal 30 and inner cover 44. Each spur 52 includes a pointed end 53 that is pressed against a thin intermediate portion 38 of seal 30. Spurs 52 are biased against the lower inner surface of inner cover 44 such that when the

internal pressure of cell 10 increases and seal 30 consequently becomes deformed by pressing upward toward inner cover 44, the pointed ends 53 of spurs 52 penetrate through the thin intermediate portion 38 of seal 30 thereby rupturing seal 30 and allowing the escape of the internally-generated gas through apertures 43.

5

A label is applied over the external surface of the battery can, for example a shrink-wrap film or an adhesive sticker that contains or supports visual information on or in a film or other label substrate.

10 The measured external and internal volumes for several batteries that were commercially available at the priority date of this application are listed in the tables shown in Figures 2A and 2B. The tables list the volumes (cc) for D, C, AA, and AAA sized batteries. The collector assembly volume and the percentage of the total cell volume that constitutes the collector assembly volume is provided in Figure 2B for those
15 commercially available batteries listed in Figure 2A. Also provided in Figure 2A is a percentage of the total cell volume that constitutes the internal volume that is available for containing the electrochemically active materials.

20 The "total cell volume" includes all of the volume, including any internal void spaces, of the battery. For the battery shown in Figure 1, the total volume ideally includes all of the cross-hatched area as shown in Figure 3A. The "internal volume" of the battery is represented by the cross-hatched area shown in Figure 3B. The "internal volume", as used herein, is that volume inside the cell or battery that contains the electrochemically active materials as well as any voids and chemically inert materials
25 (other than the collector nail) that are confined within the sealed volume of the cell. Such chemically inert materials may include separators, conductors, and any inert additives in the electrodes. As described herein, the term "electrochemically active materials" includes the positive and negative electrodes and the electrolyte. The "collector assembly volume" includes the collector nail, seal, inner cover, washer, spurs,
30 and any void volume between the bottom surface of the negative cover and the seal (indicated by the cross-hatched area in Figure 3C). The "container volume" includes the volume of the can, label, negative cover (outer cover 45), void volume between the label

and negative cover, positive cover, and void volume between the positive cover and can (shown by the cross-hatched area in Figure 3D). If the label extends onto and into contact with the negative cover, the void volume present between the label and negative cover is included in the container volume, and therefore is also considered as part of the total volume. Otherwise, that void volume is not included in either of the container volume or the total volume.

It should be appreciated that the sum total of the "internal volume", "collector assembly volume", and "container volume" is equal to the "total volume". Accordingly, the internal volume available for electrochemically active materials can be confirmed by measuring the collector assembly volume and container volume and subtracting the collector assembly volume and the container volume from the measured total volume of the battery.

Because the exterior dimensions of the electrochemical cell are generally fixed by the American National Standards Institute (ANSI) or other standards organisations, the greater the space occupied by the container, the less space that there is available within the cell for the electrochemical materials. Consequently, a reduction in the amount of electrochemical materials that can be provided within the cell results in a shorter service life for the cell. It is therefore desirable to maximise the interior volume within an electrochemical cell that is available for the electrochemically active components.

We have now found that this may be achieved by constructing an electrochemical cell where the space occupied by the container volume is minimised. More particularly, we have found that a cell construction can be provided that allows a greater internal cell volume, by reducing the volume occupied by the label.

Accordingly, in a first aspect, the present invention provides a battery comprising a can and a label, wherein the label comprises a print layer that is directly applied onto the can.

In one embodiment of the first aspect, the present invention provides a battery that comprises a can for containing electrochemically active materials including positive and negative electrodes and an electrolyte, and a label printed directly on an exterior surface of the can.

5

In a second aspect, the present invention provides a method of preparing a battery having a label on a can, comprising directly applying a print layer onto the can.

In one embodiment of the second aspect, the present invention provides a
10 method of assembling a battery including the steps of forming a can having an open end and a closed end, forming an outer cover, dispensing electrochemically active materials in the can, sealing the outer cover across the open end of the can with a layer of electrical insulation provided therebetween, and printing a label directly on the exterior surface of the can.

15

Advantageously, the diameter of the can may be correspondingly increased to allow a significant increase in the internal volume of the battery, while maintaining a predetermined total outside diameter. A further advantage is that the cell may be simpler to manufacture and that require less materials, thereby possibly having lower
20 manufacturing costs.

The present invention will be further understood by reference to the drawings, in which:

Figure 1 is a cross section of a conventional C sized alkaline electrochemical
25 cell;

Figure 2A is a table showing the relative total battery volumes and internal cell volumes available for electrochemically active materials, as measured for those batteries that were commercially available at the priority date of this application;

Figure 2B is a table showing the relative total battery volumes and collector
30 assembly volumes as measured for those batteries that were commercially available as provided in Figure 2A;

Figures 3A-3D are cross sections of a conventional C sized alkaline electrochemical cell that illustrate the total battery and various component volumes;

Figure 4A is a table showing the calculated total and internal cell volume for various batteries; and

5 Figure 4B is a table showing the calculated total volume and collector assembly volume for various batteries.

As described above, a primary objective of the present invention is to increase the internal volume available in a battery for containing the electrochemically active materials. In accordance with the present invention, a label may be lithographed directly onto the exterior surface of the battery can. By lithographing the label directly onto the exterior of the can, the internal volume of the cell may be increased since one does not have to account for the thickness of the label substrate to construct a cell that meets the ANSI or other exterior size standards.

15

As noted above, the inventive battery construction includes a directly applied print label, rather than the label substrates currently used. By "directly" is meant that no label substrate is present between the print layer and the external surface of the battery can. Current label substrates have thicknesses on the order of 75 μm (3 mils). Because such label substrates overlap to form a seam running along the length of the battery, these conventional labels effectively add about of 250 μm (10 mils) to the diameter and of 330 μm (13 mils) to the crimp height of the battery. As a result, the battery can must have a diameter that is selected to accommodate the thickness of the label seam in order to meet the ANSI or other size standards. However, by printing a lithographed label directly on the exterior surface of the can in accordance with the present invention, the diameter of the can may be correspondingly increased approximately of 250 μm (10 mils). Such an increase in the diameter of the can significantly increases the internal volume of the battery.

25

30 Figures 4A and 4B show volumes of various different types of battery constructions that are more fully disclosed in US 60/102,951 filed 2 October 1998 and US 60/097,445 filed 21 August 1998. All of the batteries listed in the tables of Figures

4A and 4B, with the exception of the beverage can constructions, include substrate labels. The internal volume of the batteries with substrate labels could be further increased, for example by 2 percent (1.02 cc) for a D sized battery, 2.6 percent (0.65 cc) for a C sized battery, 3.9 percent (0.202 cc) for an AA sized cell, and 5.5 percent (0.195 cc) for an AAA sized battery, if the labels were printed directly on the exterior of the can.

Labels may also be printed on the can using transfer printing techniques in which the label image is first printed on a transfer medium and then transferred directly onto the can exterior. Distorted lithography may also be used whereby intentionally distorted graphics are printed on flat material so as to account for subsequent stress distortions of the flat material as it is shaped into the tube or cylinder of the cell can.

Prior to printing the lithographed label, the exterior surface of the can is preferably cleaned. To enhance adherence of the print to the can, a base coat of primer may be applied to the exterior surface of the can. The print layer is then applied directly on top of the base coat on the can by known lithographic printing techniques.

The label may further comprise an electrically insulating overcoat. A varnish overcoat is preferably applied over the print layer to cover and protect the print layer, and also to serve as an electrically insulating layer. The printed label may be cured with the use of high temperature heating or ultraviolet radiation techniques.

With the use of the printed label, the thickness of the label may be significantly reduced compared with a conventional label on a substrate, to a maximum thickness of approximately 13 μm (0.5 mils).

In a particular embodiment, the printed label has a base coat layer of a thickness in the range of about 2.5 to 5 μm (0.1 to 0.2 mil), a print layer of a thickness of approximately 2.5 μm (0.1 mil), and a varnish overcoat layer of a thickness in the range of about 2.5 to 5 μm (0.1 to 0.2 mil).

By reducing the label thickness, the can is able to be increased in diameter, thereby offering an increase in available volume for active cell materials while maintaining a predetermined outside diameter of the battery.

5 While the present invention has been described above as having primary applicability to alkaline batteries, it will be appreciated by those skilled in the art that similar benefits may be obtained in batteries utilising other electrochemical systems. For example, the inventive constructions may be employed in primary systems such as carbon-zinc and lithium based batteries and in rechargeable batteries, such as NiCd,
10 metal hydride, and Li based batteries. Additionally, although the present invention has been described above in connection with cylindrical batteries, the present invention may be employed in constructing cells of any shape that can support a label, for example prismatic cells.

15 It will be understood that the embodiments shown in the drawings and described above are merely for illustrative purposes and not intended to limit the scope of the invention.

EXAMPLE

20

The total battery volume, collector assembly volume, and internal volume available for electrochemically active material for each battery are determined by viewing a Computer Aided Design (CAD) drawing, a photograph, or an actual cross section of the battery which has been encased in epoxy and longitudinally cross-
25 sectioned. The use of a CAD drawing, photograph, or actual longitudinal cross section to view and measure battery dimensions allows for inclusion of all void volumes that might be present in the battery. To measure the total battery volume, the cross-sectional view of the battery taken through its central longitudinal axis of symmetry is viewed and the entire volume is measured by geometric computation. To measure the internal
30 volume available for electrochemically active materials, the cross-sectional view of the battery taken through its central longitudinal axis of symmetry is viewed, and the components making up the internal volume, which includes the electrochemically active

materials, void volumes and chemically inert materials (other than the collector nail) that are confined within the sealed volume of the cell, are measured by geometric computation. Likewise, to determine volume of the collector assembly, the cross-sectional view of the battery taken through its central longitudinal axis of symmetry thereof is viewed, and the components making up the collector assembly volume, which include the collector nail, seal, inner cover, and any void volume defined between the bottom surface of the negative cover and the seal, are measured by geometric computation. The container volume may likewise be measured by viewing the central longitudinal cross section of the battery and computing the volume consumed by the can, label, negative cover, void volume between the label and negative cover, positive cover, and void volume between the positive cover and the can.

As mentioned, the volume measurements are made by viewing a cross section of the battery taken through its longitudinal axis of symmetry. This provides for an accurate volume measurement, since the battery and its components are usually axially symmetric. To obtain a geometric view of the cross section of a battery, the battery was first potted in epoxy and, after the epoxy solidified, the potted battery and its components were ground down to the central cross section through the axis of symmetry. More particularly, the battery was first potted in epoxy and then ground short of the central cross section. Next, all internal components such as the anode, cathode, and separator paper were removed in order to better enable measurement of the finished cross section. The potted battery was then cleaned of any remaining debris, was air dried, and the remaining void volumes were filled with epoxy to give the battery some integrity before completing the grinding and polishing to its centre. The battery was again ground and polished until finished to its central cross section, was thereafter traced into a drawing, and the volumes measured therefrom.

Prior to potting the battery in epoxy, battery measurements were taken with callipers to measure the overall height, the crimp height, and the outside diameter at the top, bottom, and centre of the battery. In addition, an identical battery was disassembled and the components thereof were measured. These measurements of components of the disassembled battery include the diameter of the current collector nail, the length of the

current collector nail, the length of the current collector nail to the negative cover, and the outside diameter of the top, bottom, and centre of the battery without the label present.

5 Once the battery was completely potted in epoxy and ground to centre through the longitudinal axis of symmetry, the cross-sectional view of the battery was used to make a drawing. A Mitutoyo optical comparator with QC-4000 software was used to trace the contour of the battery and its individual components to generate a drawing of the central cross section of the battery. In doing so, the battery was securely fixed in
10 place and the contour of the battery parts were saved in a format that could later be used in solid modelling software to calculate the battery volumes of interest. However, before any volume measurements were taken, the drawing may be adjusted to compensate for any battery components that are not aligned exactly through the centre of the battery. This may be accomplished by using the measurements that were taken
15 from the battery before cross sectioning the battery and those measurements taken from the disassembled identical battery. For example, the diameter and length of the current collector nail, and overall outside diameter of the battery can be modified to profile the drawing more accurately by adjusting the drawing to include the corresponding known cross-sectional dimensions to make the drawing more accurate for volume
20 measurements. The detail of the seal, cover, and crimp areas were used as they were drawn on the optical comparator.

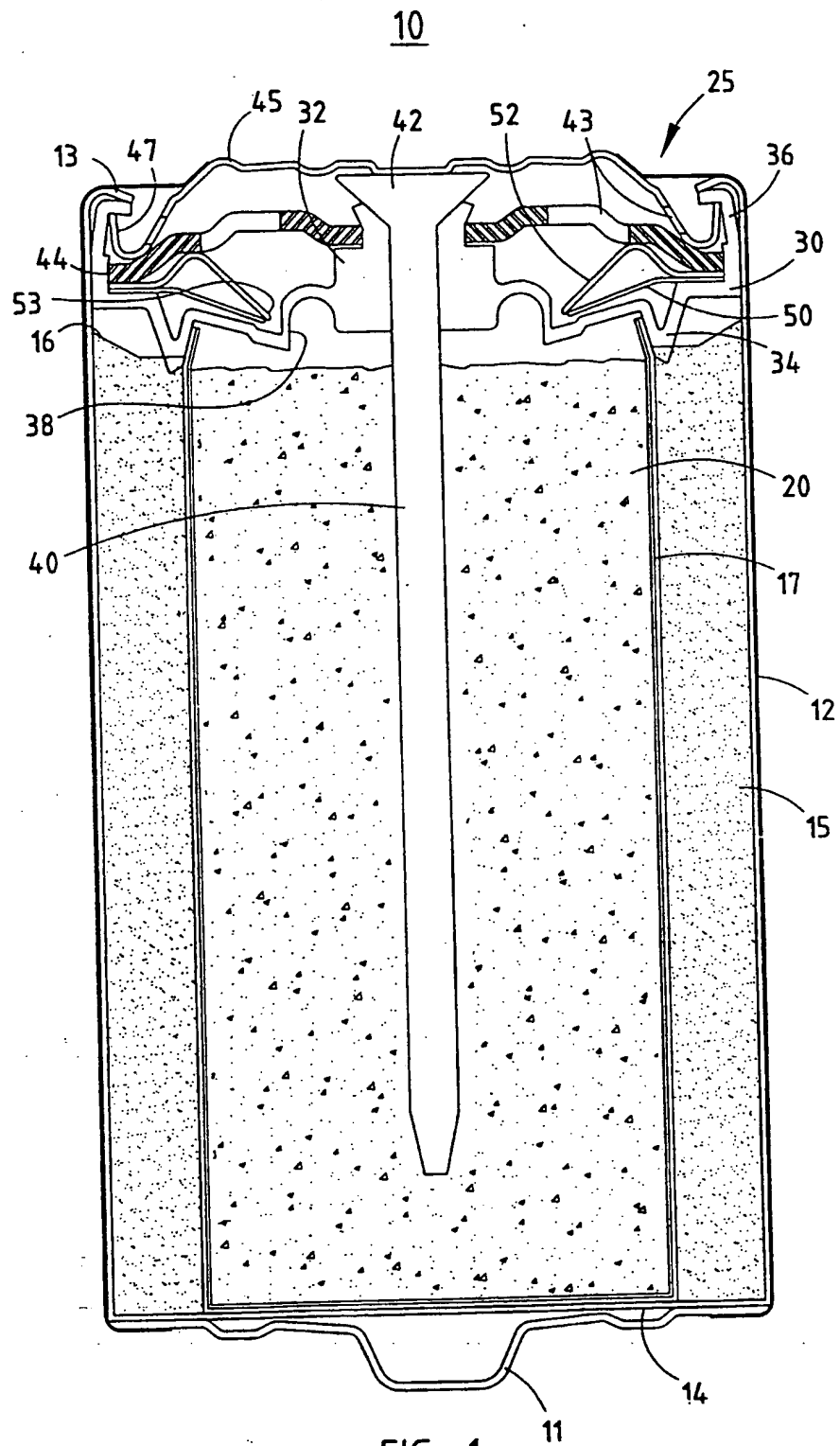
To calculate the volume measurements, the drawing was imported into solid modelling software. A solid three-dimensional volume representation was generated by
25 rotating the contour of the cross section on both the left and right sides by one-hundred-eighty degrees (180°) about the longitudinal axis of symmetry. Accordingly, the volume of each region of interest is calculated by the software and, by rotating the left and right sides by one-hundred-eighty degrees (180°) and summing the left and right volumes together an average volume value is determined, which may be advantageous in those
30 situations where the battery has non-symmetrical features. The volumes which include any non-symmetrical features can be adjusted as necessary to obtain more accurate volume measurements.

Using these techniques to measure and calculate battery volumes, it was found that the internal volume of the batteries with substrate labels could be further increased 2 percent (1.02 cc) for a D sized battery, 2.6 percent (0.65 cc) for a C sized battery, 3.9
5 percent (0.202 cc) for an AA sized cell, and 5.5 percent (0.195 cc) for an AAA sized battery, if the labels were printed directly on the exterior of the can.

CLAIMS:

1. A battery comprising a can and a label, characterised in that the label comprises a print layer that is directly applied onto the can.
- 5 2. A battery comprising:
a can for containing electrochemically active materials including positive and negative electrodes and an electrolyte; and
a label printed directly on an exterior surface of the can.
- 10 3. A battery according to claim 1 or claim 2, wherein the label comprises a lithographed label.
4. A battery according to any of claims 1 to 3, wherein the can comprises metal.
- 15 5. A battery according to claim 4, wherein the can comprises steel.
6. A battery according to any preceding claim, wherein the label is printed using a transfer printing technique in which an image of the label is printed on a transfer
20 medium and then transferred directly to the exterior surface of the can.
7. A battery according to any preceding claim, wherein the label has a maximum thickness of 13 μm (0.5 mil).
- 25 8. A battery according to any preceding claim, wherein the label includes a print layer covered by an electrical insulation layer.
9. A battery according to any preceding claim, wherein the label includes a primer layer applied directly on the can, and the print layer is applied directly on top of the
30 primer layer.

10. A battery according to any preceding claim, wherein the battery is a cylindrical battery.
11. A method of preparing a battery having a label on a can, comprising directly
5 applying a print layer onto the can.
12. A method of assembling a battery comprising the steps of:
forming a can having an open end and a closed end;
dispensing electrochemically active materials in the can; and
10 printing a label directly on the exterior surface of the can.
13. A method according to claim 11 or claim 12, wherein the label is printed on the exterior of the can using lithography.
- 15 14. A method according to claim 11 or claim 12, wherein the label is printed on the exterior of the can using transfer printing techniques.
15. A method according to any preceding claim, further comprising applying an electrical insulation layer on top of the print layer.
20
16. A method according to any preceding claim, further comprising applying a primer layer between the print layer and the can.
17. A method according to any preceding claim, wherein the label is applied to a
25 maximum thickness of 13 μm (0.5 mil).



D			C			AA			AAA		
Total Vol (cc)	Int Vol (cc)	%	Total Vol (cc)	Int Vol (cc)	%	Total Vol (cc)	Int Vol (cc)	%	Total Vol (cc)	Int Vol (cc)	%
50.38	44.16	87.7%	23.22	19.37	83.4%	7.43	6.05	81.4%	3.65	2.67	73.2%
48.19	41.48	86.1%	23.30	18.95	81.3%	7.62	6.12	80.3%	3.44	2.62	76.2%
48.36	40.59	83.9%	23.53	19.09	81.1%	7.20	5.84	81.1%	3.55	2.66	74.9%

FIG. 2A

D			C			AA			AAA		
Total Vol (cc)	Collector Ass'y Vol (cc)	%	Total Vol (cc)	Collector Ass'y Vol (cc)	%	Total Vol (cc)	Collector Ass'y Vol (cc)	%	Total Vol (cc)	Collector Ass'y Vol (cc)	%
50.38	2.51	5.0%	23.22	1.72	7.4%	7.43	0.52	7.0%	3.65	0.32	8.8%
48.19	3.43	7.1%	23.30	2.01	8.6%	7.62	0.50	6.6%	3.44	0.29	8.4%
48.36	3.80	7.9%	23.53	2.05	8.7%	7.20	0.53	7.4%	3.55	0.30	8.5%

FIG. 2B

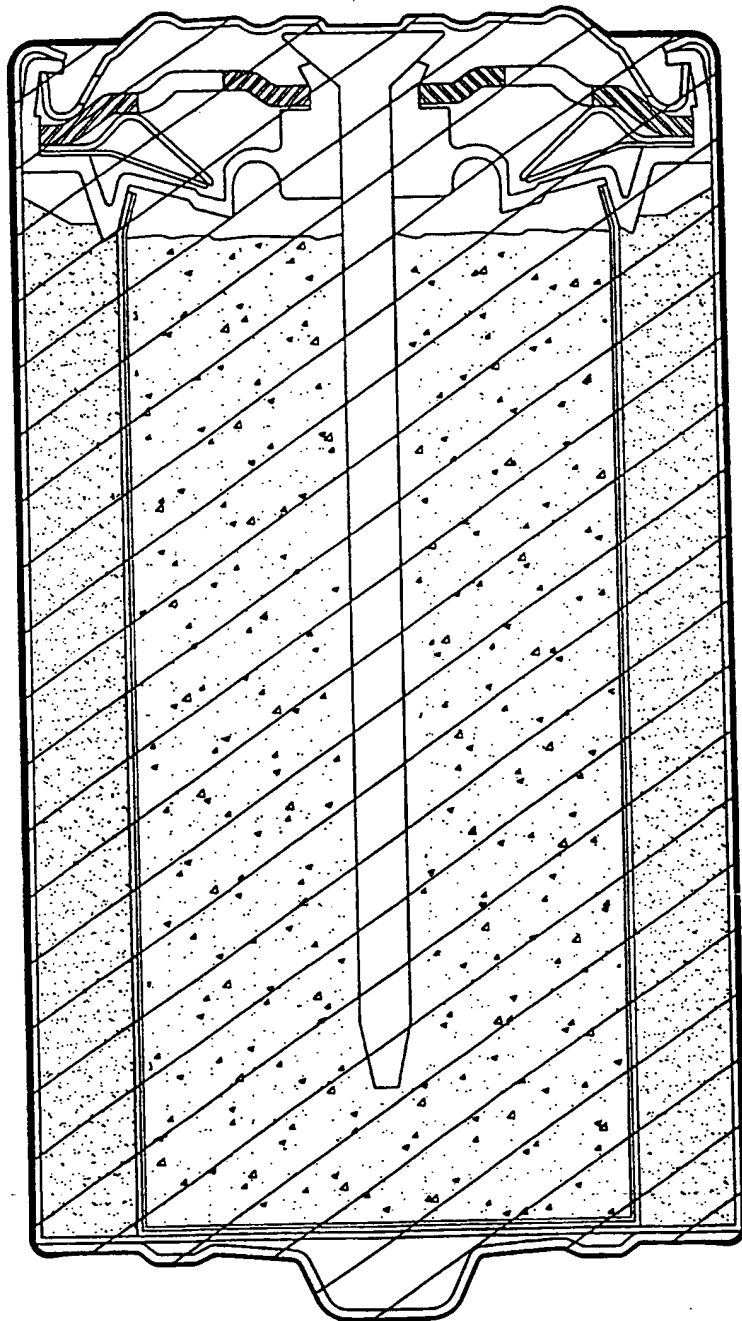


FIG. 3A

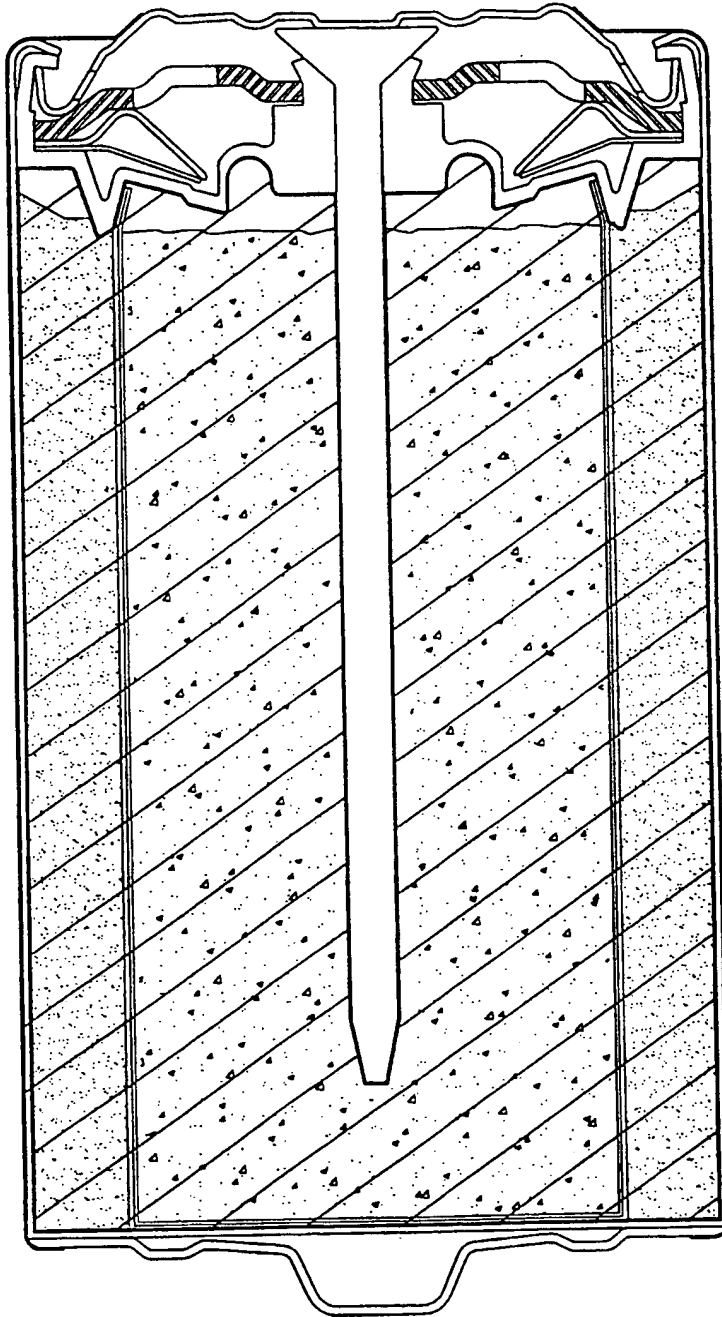


FIG. 3B

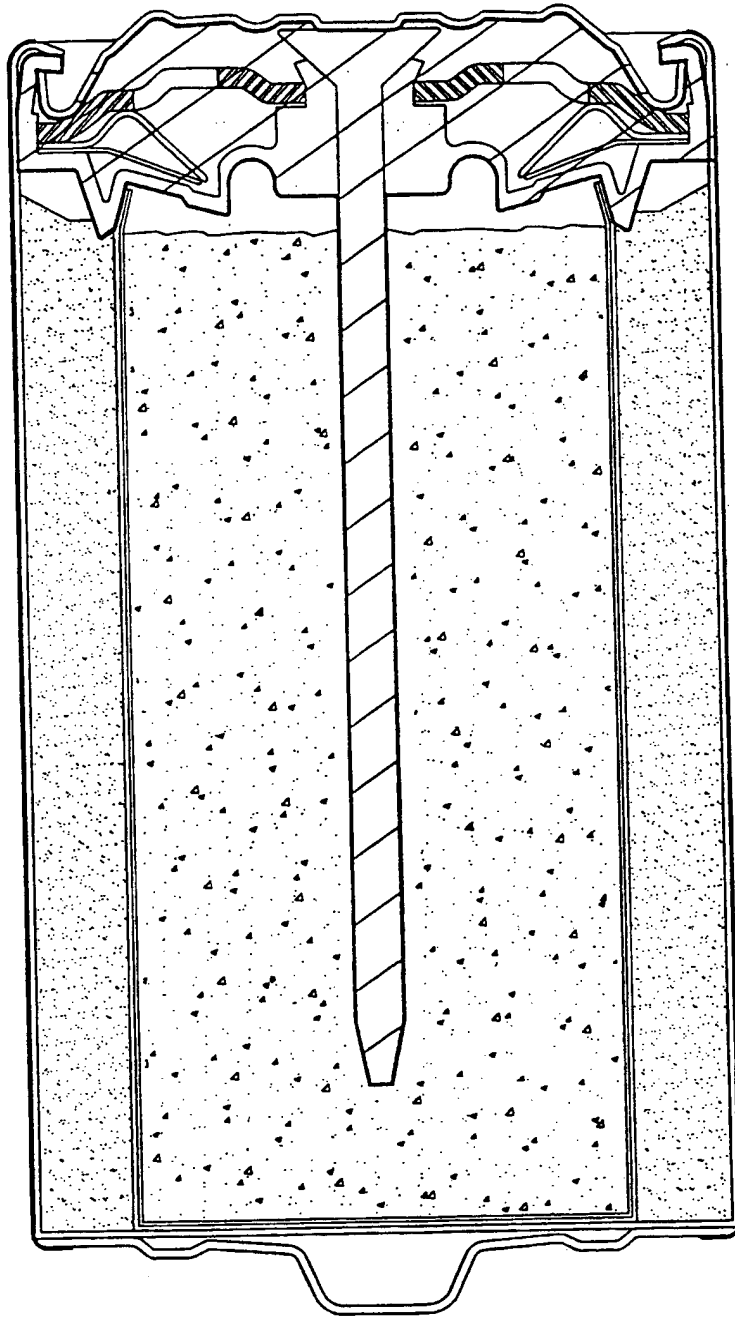


FIG. 3C

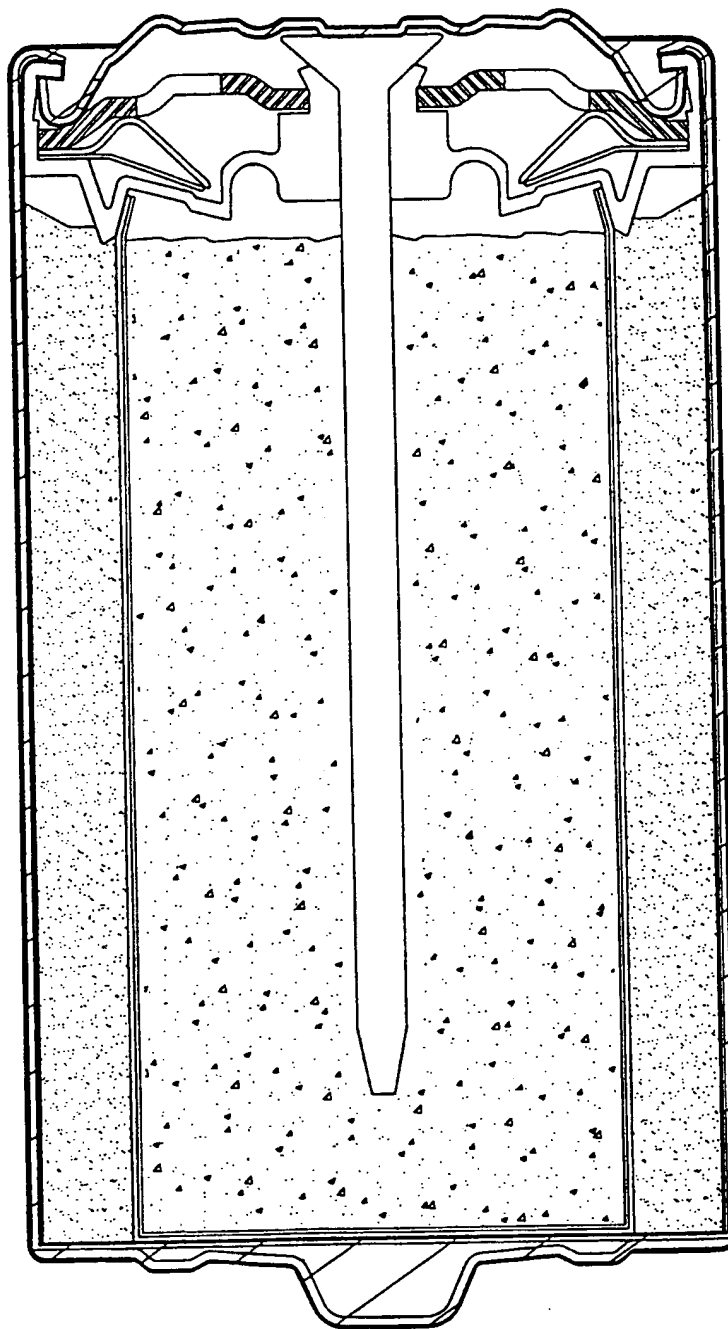


FIG. 3D

	D**				C***				AA				AAA			
	Walls	Total Vol (cc)	Int Vol (cc)	%	Walls	Total Vol (cc)	Int Vol (cc)	%	Walls	Total Vol (cc)	Int Vol (cc)	%	Walls	Total Vol (cc)	Int Vol (cc)	%
Low Profile Seal	10 mil	50.07	44.67	89.2%	10 mil	24.57	20.21	83.2%	8 mil	7.75	6.47	83.5%	8 mil	3.57	2.81	78.7%
Ultra Low Profile Seal	10 mil	50.07	45.53	90.9%	10 mil	24.57	20.92	85.1%	8 mil	7.75	6.56	84.7%	8 mil	3.57	2.90	81.3%
Ultra Low Profile Seal w/Thin Can Walls	8 mil	50.07	46.34	92.6%	8 mil	24.57	21.23	86.4%	6 mil	7.75	6.77	87.4%	6 mil	3.57	3.06	85.5%
Pressure Relief In Can Bottom	10 mil	50.07	46.82	93.5%	10 mil	24.57	21.42	87.2%	8 mil	7.75	6.88	86.2%	8 mil	3.57	3.02	84.6%
Pressure Relief In Can Bottom w/Thin Walls	8 mil	50.07	47.52	94.9%	8 mil	24.57	21.73	88.4%	6 mil	7.75	6.95	89.6%	6 mil	3.57	3.14	88.0%
Beverage Can-Type Construction*	8 mil	50.07	48.59	97.0%	8 mil	24.57	22.26	90.6%	6 mil	7.75	7.01	90.4%	6 mil	3.57	3.22	90.1%
Beverage Can With Feed Through Collector*	8 mil	50.07	48.07	96.0%	8 mil	24.57	22.01	89.6%	6 mil	7.75	6.93	89.4%	6 mil	3.57	3.18	89.1%

* Utilizes a lithographed label directly on the can -- all other constructions use a shrink wrap label.

** All the D size cells were constructed with a recessed negative cover.

** All the C size cells were constructed with a recessed negative cover and have a 10 mil diameter increase over the prior C size Energizer cells.

FIG. 4A

	D**				C***				AA				AAA			
	Walls	Total Volume (cc)	Collector Assy Vol (cc)	%	Walls	Total Volume (cc)	Collector Assy Vol (cc)	%	Walls	Total Volume (cc)	Collector Assy Vol (cc)	%	Walls	Total Volume (cc)	Collector Assy Vol (cc)	%
Low Profile Seal	10 mil	50.07	2.65	5.3%	10 mil	24.57	1.81	7.4%	8 mil	7.75	0.36	4.6%	8 mil	3.57	0.24	6.7%
Ultra Low Profile Seal	10 mil	50.07	1.89	3.8%	10 mil	24.57	1.10	4.5%	8 mil	7.75	0.25	3.2%	8 mil	3.57	0.15	4.1%
Ultra Low Profile Seal w/Thin Can Walls	8 mil	50.07	1.70	3.4%	8 mil	24.57	0.97	3.9%	6 mil	7.75	0.19	2.5%	6 mil	3.57	0.12	3.4%
Pressure Relief In Can Bottom	10 mil	50.07	1.00	2.0%	10 mil	24.57	0.75	3.1%	8 mil	7.75	0.13	1.6%	8 mil	3.57	0.06	1.7%
Pressure Relief In Can Bottom w/Thin Walls	8 mil	50.07	1.00	2.0%	8 mil	24.57	0.75	3.1%	6 mil	7.75	0.13	1.6%	6 mil	3.57	0.06	1.7%
Beverage Can-Type Construction*	8 mil	50.07	0.78	1.6%	8 mil	24.57	0.63	2.6%	6 mil	7.75	0.07	0.9%	6 mil	3.57	0.06	1.6%
Beverage Can With Feed Through Collector*	8 mil	50.07	1.30	2.6%	8 mil	24.57	0.88	3.6%	6 mil	7.75	0.15	1.9%	6 mil	3.57	0.09	2.6%

* Utilizes a lithographed label directly on the can -- all other constructions use a shrink wrap label.

** All the D size cells were constructed with a recessed negative cover.

** All the C size cells were constructed with a recessed negative cover and have a 10 mil diameter increase over the prior C size Energizer cells.

FIG. 4B

INTERNATIONAL SEARCH REPORT

International Application No

PC/US 99/18636

A. CLASSIFICATION OF SUBJECT MATTER

IPC 7 H01M2/02

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 7 H01M

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP 0 837 514 A (VARTA BATTERIE) 22 April 1998 (1998-04-22) the whole document	1-17
X	PATENT ABSTRACTS OF JAPAN vol. 015, no. 114 (E-1047), 19 March 1991 (1991-03-19) & JP 03 004546 A (MATSUSHITA ELECTRIC IND CO LTD), 10 January 1991 (1991-01-10) abstract	1,2,4,8, 10-12,15
A	EP 0 841 709 A (ROTANOTICE) 13 May 1998 (1998-05-13) claims 1-11	1-17
A	GB 2 241 375 A (ULTRAMARK ADHESIVE PRODUCTS LI) 28 August 1991 (1991-08-28) claims 1-10	1-17

☐ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

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"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search

18 November 1999

Date of mailing of the international search report

26/11/1999

Name and mailing address of the ISA

European Patent Office, P.B. 5818 Patentlaan 2
NL - 2280 HV Rijswijk
Tel. (+31-70) 340-2040, Tx. 31 651 epo nl,
Fax: (+31-70) 340-3016

Authorized officer

Battistig, M

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No

PCT/US 99/18636

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